Exciton-Plasmon Interactions and Fano Resonances in Nanostructures

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Coulomb and electromagnetic interactions between excitons and plasmons in nanocrystals cause several interesting effects: energy transfer between nanoparticles (NPs), plasmon enhancement, reduced exciton diffusion in nanowires (NWs), exciton energy shifts, Fano interference effect, and non-linear phenomena [1-3]. Using transport equations for excitons, we model exciton transfer in NWs and explain the origin of the blue shift of exciton emission observed during recent experiments with hybrid NW-NP assemblies [2]. We also look at optical responses of artificial light-harvesting complexes composed of chlorophylls, bacterial reaction centers, and NPs [3]. We show that, using superior optical properties of metal and semiconductor NPs, it is possible to strongly enhance the efficiency of light harvesting in such complexes [3]. An interaction between a discrete state of exciton and a continuum of plasmonic states can give rise to interference effects (Fano-like asymmetric resonances and anti-resonances). These interference effects greatly enhance visibility of relatively weak exciton signals and can be used for spectroscopy of single nanoparticle and molecules. In a nonlinear regime, the Fano effect becomes strongly amplified and results in interesting non-linear responses [4]. If an exciton-plasmon system includes chiral elements (chiral molecules or nanocrystals), the Fano-like interference effects strongly enhance the circular dichroism signals [5,6]. In conclusion, our theory explains current experimental results and also provides rationale for future experiments and applications. Potential applications of dynamic exciton-plasmon systems include sensors and light-harvesting.

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